pISSN: 2321 – 9742

The Sapience

Advances in Physical Science Research

Study of Birefringence and Refractive Index for Cholest-5-en-3-ol (3β)-, Propanoate

Srashti Saxena[2], Abhay Saxena[1*], R. S. Yadav[1] and Sanjay Kr. Sharma[2]

[1]Department of Physics, D.A.V. (P.G.) College, Kanpur

[2]Department of Physics, D. B. S. College, Kanpur

[*]Corresponding Author: dhp_abhay@yahoo.com

Abstract

The measurements of refractive indices (n_e, n_o) and birefringence (Δn) have been done for Cholest-5-en-3-ol (3β)-, Propanoate (Cholesteryl Propanoate) with the variation of temperature. The change in density with temperature has also been measured. The refractive index and density data showed almost same transition temperature.

Keywords: Liquid Crystal, Refractive Index, Birefringence, Molecular Interaction.

1. Introduction

Liquid crystal can be defined as the special state of matter controlled by the temperature range. It is also said as mesomorphic state of the matter. The particular temperature range covers the beauty of this matter. Over the last forty years liquid crystals have attracted much interest and considerable progress has been made to our knowledge in the field. At the phase transition point the molecular properties like viscosity, specific heat, and density, etc. change abruptly [1-3]. Such a study is very important when even the microscopic picture of order parameter is no longer adequate [4-6].

The optical study of cholesteryl compound their mixtures have been done by many groups. Chandel et al. reported Study of Binary Mixture of Cholesteric Liquid Crystals [7], the group also reported similar studies for other type of liquid crystals [8-11]. P. Brahma and Sushmita Sen studied dielectric properties of liquid crystal samples at different frequencies [12]. Shohei Naemura and K. Tarumi studied the optical birefringence (Δn) [13]. Rajiv Manohar and Abhishek Kumar Srivastava experimentally studied the Dielectric, optical and thermodynamical properties of liquids crystal sample exhibiting SmA Phase [14].

Measurements of refractive indices (n_e, n_o) and birefringence (Δn) have been done of pure cholesteryl propanoate with change in temperature [15-16]. The change in density with temperature has also been measured [17-18]. The change in density with temperature is similar close to the reported values elsewhere [19].

In the present study we have used cholesteryl propanoate, called as Cholest-5-en-3-ol (3β)-, Propanoate. The cholesteryl propanoate forms a cholesteric liquid crystal with helical structure [Fig-1]. Cholesteric propanoate was among the first materials in which liquid crystal properties were discovered. It appears as white powder in physical state with melting point ranging from 95°C to 99°C. It is insoluble in water. Its molar weight is 442.72 and chemical formula is $C_{30}H_{50}O_2$. The ordinary refractive index (n_o) is greater than the extraordinary refractive index (n_e) so this sample is optically negative [20].

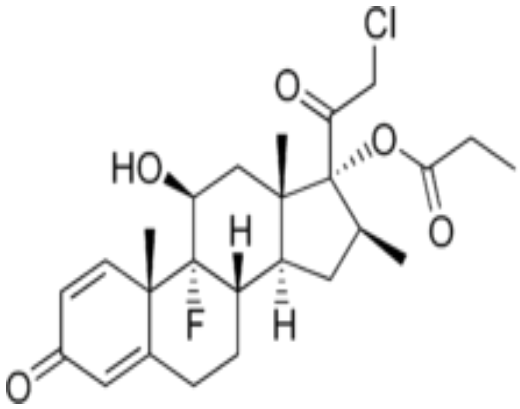

Fig. 1 - Structure of Cholesteryl Propanoate

2. Material and Methods

The material for the present investigation was procured from Dr. C. P. Singh, Associate Professor, R.P.D.C., Kamalganj, Farrukhabad India. It was used without further purification. The refractive index (n) of liquid crystal can be determined easily using an Abbe's refractometer. However, the study of birefringence becomes necessary as a fundamental property. The accurate measurement of critical angle is very essential to understand the working of Abbe's refractometer. The critical angle for a boundary separating two optical media is defined as the smallest angle of incidence in the medium of greater refractive index for which the light is internally reflected. Thus, by knowing the value of the critical angle we are able to measure the refractive index of the liquid. The ordinary refractive index (n_o) and extraordinary refractive index (n_e) can be determined by Abbe's refractometer with the help of polarized light. But, whenever one of the refractive indices is out of the range of Abbe's refractometer, some other technique has to apply. The temperature of the sample was varied by specific means to measure the refractive indices at different temperatures. With the help of ordinary refractive index (n_o) and extra ordinary refractive index (n_e) we can calculate the birefringence (Δn).

$$\Delta n = n_o - n_e$$

The density measurements for the liquid crystal have been taken using a graduated container calibrated with distilled water. The container was placed in a glass jacket in which the water was circulated from the thermostats to maintain the temperature. The experimental liquid crystal is filled in the capillary tube and its mass was measured and after maintaining the temperature in the water jacket the rise in height of capillary tube was read for the given mass and in this way density at each temperature can be measured.

3. Results and Discussion

The ordinary refractive index (n_o) and extraordinary refractive index (n_e) are determined for the sample by Abbe's refractometer. Values of refractive indices with corresponding change in temperature have been taken and graphs are plotted between temperature and refractive indices. Figure-2 shows that there is rapid change in extraordinary refractive index (n_e) and ordinary refractive index (n_o) at transition temperatures as compared to the any specific state.

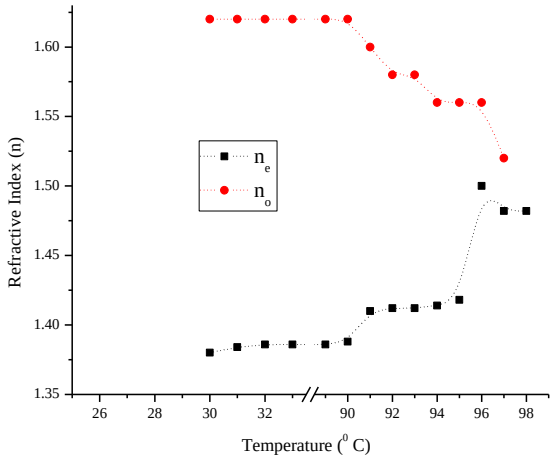

Fig. 2 - Variation of Refractive Indices (n_e, n_o) with Temperature

Figure 3 shows that birefringence (Δn) changes sharply at transition temperature, which shows the changed optical properties after this near transition point. The density changes shown in figure - 4 are nearer to the literature values. The birefringence is one of the most important parameters of a liquid crystal and govern approximately all its physical properties.

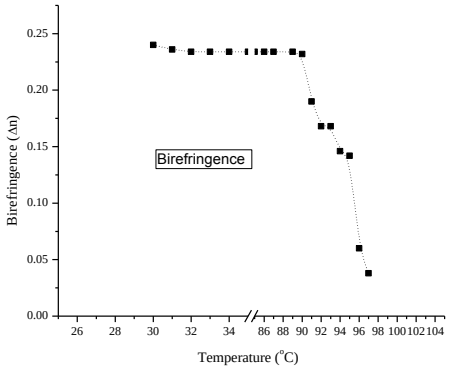

Fig. 3 - Variation of Birefringence (Δn) with Temperature

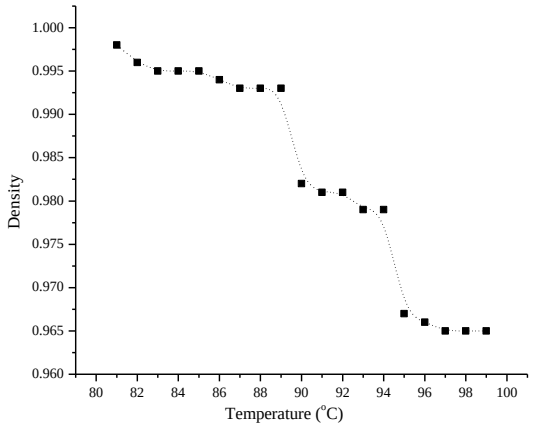

Fig. 4 - Variation of Density (ρ) with Temperature

4. Conclusion

In pure state near the transition points the sample exhibits some dramatic property which is important for the electronic applications. The optical properties fluctuate as a function of temperature. It can also be concluded that cholesteryl propanoate shows very poor control over the molecular interaction at the higher temperature.

5. Acknowledgment

One of the authors, Dr. Sanjay Kr. Sharma, is thankful to UGC, New Delhi for financial assistance under the Major Research Project in Department of Physics, D.B.S. College Kanpur.

6. References

1. S. Chandrashekhar, Liquid Crystals, Cambridge University Press, 1977.
2. S. Delica, M. Estonactoc, M. C. Micaller, L. Cada, MMAIJ, 4(1); April 2008.
3. P. G. de Gennes, J. Prost; The Physics of Liquid Crystals, Clarendon Press, 1995

4. Abhay Saxena, Study of paraphernalia cauterizations of Liquid crystals, Journal of Purvanchal Academy of Physical Sciences, 17, 35 – 38, 2011.
5. Abhay Saxena, Manoj Johri and R.S. Yadav, Study of the Technological Importance & Applications of Liquid Crystal, Journal of Purvanchal Academy of Physical Sciences,16, 6-11, 2010.
6. R. Manohar, M. Gupta, J. P. Shukla; Phase transition studies of some cholesteric liquid crystals and their mixtures using dielectric, optical transmittance and density measurement techniques J. Phys. & Chem. Solids, 61, 1465, 2000.
7. V. S. Chandel, A. K. Singh, S. Manohar, J. P. Shukla, and R. Manohar, Phase Transition Study of Binary Mixture of Cholesteric Liquid Crystals, Journal of Advanced Research in Physics, 3(2),021203, (pages 1-6) 2012**.**
8. S. Manohar, S. N. Shukla, V. S. Chandel, J. P. Shukla, R. M., Dielectric and Optical Study of Polymer Nematic Liquid Crystal Composite, Transactions on Electrical and Electronic Materials, 14(3),111-115, 2013.
9. S. Manohar, S. N. Shukla, V. S. Chandel, J. P. Shukla, R. M.,, Comparative Dielectric and Optical Study of a Pure and Polymer Doped Liquid Crystal Showing Smectic A Phase, J Sci. A, 20(3), 317-322, 2012.
10. V. S. Chandel, S. Manohar, J. P. Shukla, and R. Manohar, Optical Studies of a Pure and Dye Doped Nematic Liquid Crystal E-24, Transactions on Electrical and Electronic Materials, 13(5), 221-224, 2012.
11. V. S. Chandel, R. Manohar and J. P. Shukla, Refractive Indices, Order Parameter And Density Study Of BKS/B07 Nematic Liquid Crystal, Analele UniversităŃii din Bucuresti – Chimie (serie nouă), 20(02), 155 – 163, 2011.
12. S. Sen, P. Brahma, S.K. Roy, and S.B. Roy, Dielectric anisotropy, birefringence and order parameter of three liquid crystals in the nematic state, Acta Phys. Pol., A, 65, 47 1984.
13. K. Tarumi, M. Bremer and T. Geelhaar, Annu. Recent Liquid Crystal Material Development for Active Matrix Displays, Rev. Mater. Sci. 27, 423-441, 1997.
14. A. K. Srivastava, R. Manohar, J. P. Shukla, Refractive Indices, Order Parameter and Principal Polarizability of Cholesteric Liquid Crystals and Their Mixtures, Mol. Cryst. Liq. Cryst., 454, 225-234, 2006.
15. M. F. Grebyonkin, G. A. Beresnev, V. V. Belyaev; Visco-elastic properties of liquid crystalline mixtures, Mol.Cryst. Liq. Crys., 103, 1, 1983.
16. G. H. Brown (Editor); .Advance in Liquid Crystals, Academic Press, New York, 2, 1975.
17. M. F. Vuks; Optics and Spectroscopy, 20, 361, 1966.
18. V. P. Arora, S. Prakash, V. K. Agrawal; Ind. J. Pure & Appl. Phys., 30, 406, 1992.
19. K. Bhowmick, A. Mukhopadhyay, C. D. Mukherjee, Orientational Order Parameter as a Function of Temperature of Cyanocyclohexyl Cyclohexanes, Mol. Cryst. Liq. Crys., 366, 229-238, 2001.
20. R. Vora, A. Prajapati, J. Kevat, Effect of Terminal Branching on Mesomorphism, Mol. Cryst. Liq. Cryst., 357, 229-237, 2001.